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Latent Prints: A Perspective on the State of the Science
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Latent Prints: A Perspective on the State of the Science

Peter E. Peterson
Physical Scientist/Forensic Examiner
Latent Print Operations Unit
FBI Laboratory
Quantico, Virginia

Cherise B. Dreyfus
Supervisory Physical Scientist/Forensic Examiner
Latent Print Operations Unit
FBI Laboratory
Quantico, Virginia

Melissa R. Gische
Physical Scientist/Forensic Examiner
Latent Print Operations Unit
FBI Laboratory
Quantico, Virginia

Mitchell Hollars
Program Manager
Latent Print Support Unit
FBI Laboratory
Quantico, Virginia

Maria Antonia Roberts
Research Program Manager
Latent Print Support Unit
FBI Laboratory
Quantico, Virginia

Robin M. Ruth
Physical Scientist/Forensic Examiner
Latent Print Operations Unit
FBI Laboratory
Quantico, Virginia

Heather M. Webster
Physical Scientist/Forensic Examiner
Latent Print Operations Unit
FBI Laboratory
Quantico, Virginia

Greg L. Soltis
Chief
Latent Print Operations Unit
FBI Laboratory
Quantico, Virginia

Introduction

For more than 100 years, the science of latent print examination has provided a powerful tool in the investigation of crime. Given its early use, it is not surprising that the latent print discipline developed a period of relatively unquestioned

acceptance. However, the recent introduction of newer forensic sciences such as DNA analysis and the widespread attention given to some errors that have occurred within these disciplines have lead to increased scrutiny of all forensic sciences (Budowle et al. 2009). Such scrutiny is healthy and desirable in any scientific endeavor because it generally leads to the advancement of the sciences. The science of latent prints is currently undergoing review both internally and externally in response to such scrutiny and will continue to evolve.

In this article we review the latent print discipline by addressing many of the fundamental topics associated with latent print examination. These topics include:

- The basic premises of persistence and individuality.
- The ACE-V (Analysis, Comparison, Evaluation, and Verification) methodology.
- Standards for the conclusions in latent print examinations.
- Standards for the sufficiency of friction ridge impressions for individualization.
- The role(s) of statistical models in the latent print discipline.
- Errors and error rates in latent print examination.
- Quality assurance and documentation standards in the latent print discipline.
- The training and qualifications of latent print examiners.
- The Scientific Working Group on Friction Ridge Analysis, Study and Technology (SWGFAST).

In the following sections we define each topic, identify issues of concern, clarify issues of confusion, and make recommendations for the advancement of the science. The content of this article should not be construed as a comprehensive review of the entire latent print discipline, nor is it expected that every member of the latent print community will agree with every statement made herein. We wrote this article from our perspective as FBI Laboratory latent print examiners. Other agencies and laboratories may vary in policies and practices.

Persistence and Individuality

The latent print discipline is founded on the premises of the individuality and persistence of friction ridge skin (Wertheim and Maceo 2002). These particular characteristics of friction ridge skin were first observed as early as the 1600s, but they were more substantially established after several studies conducted in the late 1800s by such pioneers as Dr. Henry Faulds and Sir Francis Galton (Ashbaugh 1999). The results of these studies provided the initial support for the tenet that friction ridge skin could be used to individualize. More scientifically rigorous studies of the individuality and persistence of friction ridge skin have been conducted since these early studies, and research is ongoing in both of these areas (Berry et al. 1989; Maltoni et al. 2003).

Today, the premises of the persistence and individuality of friction ridge skin are well supported. The most effective support lies in an understanding of the development of the friction ridge skin during fetal growth. Research has shown that arrangements of friction ridge skin are initiated and subsequently develop through a process of differential growth at the interface between the epidermal and dermal layers of the skin, thereby accounting for their “infinite” variability (i.e., individuality) (Babler 1987, 1991). Research has also shown how the structure of the skin allows continual renewal throughout a person’s lifetime of the specific friction ridge arrangements (i.e., persistence) (Cummins 1967; Hale 1952).

Additional studies also support the premises of the persistence and individuality of friction ridge skin. Empirical studies of fingerprint persistence have shown that friction ridge arrangements do not change with time, barring the formation of a scar resulting from damage or injury severe enough to disrupt the friction ridge template located at the basal layer of the epidermis (Faulds 1912; Maceo 2005). The individuality of friction ridge arrangements is supported, albeit only generally and using only a portion of the observed variation, by numerous statistical models of fingerprint individuality as well as by the study of the fingerprints of twins. In practice, no two people have been found to have the same fingerprints, nor has any individual been found to have the same fingerprints on different fingers. In addition, twin studies have shown that, although there is a higher degree of concordance of pattern classification between twins, each twin has unique fingerprints (Lin et al. 1982; Roberts et al. manuscript in preparation; Srihari et al. 2008).

In practice, examiners do not compare friction ridge skin directly; they compare two-dimensional impressions made by the friction ridge skin. This limitation of the science introduces two additional considerations to the practice of friction ridge examination: whether an impression accurately transfers the unique features of the friction ridge skin and what amount of information must be present in an impression to achieve individuality.

The friction ridge skin is a three-dimensional, pliable surface. The information present on the friction ridge skin can be

affected by, or lost during, the translation from three dimensions to two. In this translation, any number of factors, such as pressure or the amount of substance being transferred, may affect the quantity and/or quality of the information contained in the resulting impression. Despite the effects of these various factors on the appearance of friction ridge impressions, controlled recordings from the friction ridge skin have shown that the information contained in friction ridge impressions does translate reliably as a true and accurate representation of what appears on the friction ridge skin (FBI Laboratory manuscript in preparation). Even though examiners are trained to recognize the factors that may affect the translation of information (Ashbaugh 1999), further study into all of the issues affecting the quality of a latent print, and the effect of quality on sufficiency, is warranted.

ACE-V

When performing examinations, latent print examiners follow a four-step process: Analysis, Comparison, Evaluation, and Verification (ACE-V). ACE-V is not a novel scientific concept, nor is it specific to the latent print discipline. It is a general process that can be followed in any endeavor involving the comparison of two (or more) objects. R. A. Huber first articulated ACE in 1959 for use in examining questioned documents (Huber 1959). Although the ACE-V process has always been used in the latent print community, it has only been articulated as "ACE-V" for approximately the last 15 years (Ashbaugh 1991, 1994, 1999; SWGFAST 2002a).

The ACE-V process, more generally known as the ACE-V methodology, is a series of steps found within the scientific method (Reznicek et al. manuscript in preparation). The scientific method is a formula used to reduce subjectivity in any scientific endeavor. The steps of the scientific method have been described in different ways, but each description incorporates the same fundamental concepts with some organizational differences. The scientific method generally can be expressed by the following steps:

1. Make an initial observation.
2. State the problem or question.
3. Generate a hypothesis.
4. Conduct tests.
5. Generate conclusions based on the data.
6. Confirm the process and conclusion through repetition by others.
7. Record and/or present the conclusions. (Reznicek et al. manuscript in preparation)

Friction ridge examination begins when an examiner observes friction ridge detail on an item of evidence. After making this initial observation, the examiner asks, "What is the source of this latent print?" The examiner then generates a testable hypothesis to assist in answering the question and chooses a single source to represent the subject. This source is a "known exemplar." One hypothesis will therefore be that the latent print did originate from the same source as the known print. The alternate hypothesis is consequently that the latent print did not originate from the same source as the known print. In latent print examination, the examiner attempts to disprove (falsify) the primary hypothesis that a latent print and a known print originated from the same source and, if successful, accepts the alternate hypothesis that the two prints have different sources.

At this point in friction ridge examination, testing begins. The first step in the testing phase is analysis, which involves gathering all of the information available in a print to determine if sufficient quality and quantity exist for the print to be individualized (see Sufficiency section for additional discussion). If the examiner determines that the information is of sufficient quality and quantity, the print is declared "of value" for individualization.

After gathering all of the data available in the unknown (latent) print, the examiner also analyzes the known print. If both prints possess sufficient quantity and quality of information for individualization, comparison of the two prints can begin. Comparison entails examining the information gathered in the analyses of the two prints to discern similarities and differences in their friction ridge arrangements.

After fully comparing the two prints, the examiner can reach conclusions based on all of the information present. This is the evaluation phase of ACE-V. Three conclusions can be reached in friction ridge examinations: *individualization, exclusion,* and *inconclusive* (see Standards for Conclusions section for additional discussion) (SWGFAST 2002a, 2003).

The last phase of ACE-V is known as verification. In this phase, another examiner performs an independent analysis, comparison, and evaluation of the two prints in question. This is akin to replication in other sciences. That is, scientists use the information from published research to repeat experiments to determine whether they will obtain the same results as those reported in the research, thus either verifying or refuting the previous scientists' conclusions.

Lastly, the scientific method prescribes recording or presenting the results of the scientific endeavor. Examiners accomplish

this when they report the results of their examinations, as well as when they testify in court.

Standards for Conclusions

Within the forensic latent print discipline, examiners may reach three mutually exclusive conclusions: individualization (identification), exclusion, and inconclusive (SWGFAST 2003). SWGFAST has established specific standards for these three conclusions that have achieved general acceptance within the latent print community. These standards specifically define each conclusion, relate the requisite considerations of the standards, and provide the basic principles upon which the standards are based. Unlike other forensic disciplines with varying degrees of association (see Scientific Working Group on Shoeprint and Tire Tread Evidence [SWGTREAD] 2006), friction ridge impressions are only individualized, excluded, or inconclusively compared. Probable or possible identification conclusions are outside the acceptable limits of the friction ridge identification science (SWGFAST 2006) (see Statistics and Probability Modeling section for additional discussion). The FBI Latent Print Unit adheres to the *SWGFAST Standards for Conclusions* (2003).

Individualization

Individualization is, “The determination of an examiner that there is sufficient quality and quantity of detail in agreement to conclude that two friction ridge impressions originated from the same source” (SWGFAST 2009). The SWGFAST standard for individualization follows.

> “1. Individualization (Identification):
> The standard for individualization is agreement of sufficient friction ridge details in sequence.
>
> 1.1 Conditions that shall be satisfied:
>
> 1.1.1 Determined by a competent examiner, and
>
> 1.1.2 Applied to a common area in both impressions, and
>
> 1.1.3 Based on the quantity and quality of the friction ridge details, and
>
> 1.1.4 Absent any discrepancy, and
>
> 1.1.5 Reproducible conclusion.
>
> 1.2 Basic principles:
>
> 1.2.1 There is no scientific basis for requiring that a predetermined number of corresponding friction ridge details be present in two impressions in order to effect individualization.
>
> 1.2.2 Individualization is supported by the theories of biological uniqueness and permanence, probability modeling, and empirical data gained through more than one hundred years of operational experience.” (SWGFAST 2003)

To achieve source attribution, both the friction ridge impression and known exemplar must have sufficient quality and quantity of information. Because of the infinite combinations of friction ridge features and the configuration of these features with respect to the arrangement of the ridges, no predetermined amount of area or quantity of features is prerequisite to reaching an individualization conclusion (International Association of Identification [hereafter “IAI”] 1973; Margot and German 1995; SWGFAST 2003). A qualified examiner determines sufficiency based on an educated assessment of the objective information present in the impressions (see Sufficiency section for additional discussion).

According to the American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB), “When associations are made, the significance of the association shall be communicated clearly and qualified properly in the report” (ASCLD/LAB 2006a). In the friction ridge discipline, an individualization is often reported as, “One latent fingerprint detected on a demand note has been identified as a fingerprint of JOHN DOE.” Similarly, when testifying, an examiner often describes the individualization conclusion with a statement such as, “The latent print on Government’s Exhibit 10, a revolver, and the

fingerprint recorded in the right index finger block on the fingerprint card bearing the name 'John Doe' originated from the same source."

These statements relate the specificity of the conclusion but do not address the rigorous standard under which this conclusion is effected. An individualization conclusion conveys that two prints originated from the same source and, by direct inference, that the source was at some time in contact with the particular item(s). An individualization conclusion does not relate the significance of this contact or the time frame during which the contact occurred. The trier of fact resolves these determinations based on additional evidence and testimony presented at trial.

"2. Exclusion:
The standard for exclusion is disagreement of friction ridge details.

2.1 Conditions that must be satisfied:

2.1.1 Determined by a competent examiner, and

2.1.2 Applied to all comparable anatomical areas, and

2.1.3 Presence of a discrepancy, and

2.1.4 Based on sufficient quantity and quality of the friction ridge details, and

2.1.5 Reproducible conclusion.

2.2 Basic principles:

2.2.1 The presence of one discrepancy is sufficient to exclude.

2.2.2 Distortion is not a discrepancy and is not a basis for exclusion.

2.2.3 Exclusion is supported by the theories of biological uniqueness and permanence, probability modeling, and empirical data gained through more than one hundred years of operational experience." (SWGFAST 2003)

Because of the pliability of friction ridge skin, no two impressions from the same finger will be identical in every detail. A competent examiner is trained to recognize the difference between distortion within the impression and a true discrepancy and will be able to explain this distinction in court (SWGFAST 2002c).

When reporting or testifying to an exclusion decision, an examiner may state, "The latent print on Government's Exhibit 10, a revolver, is not a fingerprint of John Doe." The statement conveys the specificity of the conclusion but does not address the rigorous standard under which this conclusion is effected.

An exclusion conclusion conveys only that the questioned print did not originate from the specified source. This conclusion does not imply that the source did not have contact with the particular item(s), because it is possible for an individual to touch or handle an item and not leave a latent print suitable for comparison purposes.

Inconclusive

A conclusion of inconclusive indicates "that neither sufficient agreement exists to individualize nor sufficient disagreement exists to exclude" (SWGFAST 2009). The SWGFAST standard for inconclusive follows.

"3. Inconclusive:
The standard for an inconclusive finding is the absence of sufficient friction ridge details to effect a conclusion of individualization or exclusion.

3.1 Conditions that must be satisfied:

3.1.1 Determined by a competent examiner, and

3.1.2 Based on quantity and quality of the friction ridge details, and

3.1.3 Insufficient agreement or disagreement in the friction ridge details, and

3.1.4 Reproducible conclusion." (SWGFAST 2003)

Inconclusive decisions typically occur because the corresponding areas of friction ridge detail are absent or not interpretable (Federal Bureau of Investigation [hereafter "FBI"] 2007). For example, if the questioned print is from the extreme tip area of a finger and the corresponding area is not captured on the known exemplar, then an inconclusive decision would be reached. At the FBI, inconclusive decisions are reported in a statement such as, "The latent print was inconclusively compared with the fingerprints of John Doe." In court, an examiner may testify to an inconclusive conclusion with a statement such as, "I was not able to either individualize or exclude John Doe as the source of the latent print(s)." The statement conveys the conclusion well but does not address the basis for the conclusion.

When presenting scientific testimony within the legal arena, forensic latent print experts may find it difficult to express technical scientific matters in a concise, yet meaningful and effective manner. Qualitative statements relate the specificity of the conclusion but do not address the rigorous standards under which the conclusion was effected, nor do they explain the significance of the conclusion. When reporting results, a forensic latent print examiner must be able to explain the basis for any conclusion reached, as well as the significance of that conclusion. It is the responsibility of the friction ridge community, working in concert with the legal community, to determine how to most effectively relate the basis, standards, significance, and limitations of latent print examiner conclusions.

Sufficiency

Integral to the standards for conclusions is the concept of *sufficiency*, or how much information is needed to support the statement of "identification of a single source" (SWGFAST 2002a). Historically, this concept had been addressed by requiring a specific minimum number of ridge characteristics, or "points," to be present in an impression to effect an individualization conclusion. Some of these point standards were loosely based on rudimentary statistics (Galton 1892; Henry 1900), whereas others were based upon anecdotal evidence (Champod 1995; Champod et al. 1993; Locard 1914). A general lack of agreement over what constituted sufficiency led to the institution of several different point standards around the world. Subsequent review of these point standards found them to be arbitrary and without scientific basis (Evett and Williams 1995; IAI 1973; Margot and German 1995). It was determined that sole reliance on ridge characteristics—defined as ending ridges, bifurcations, and dots—ignored a wealth of additional information considered during the analysis and comparison of latent prints. As a result, point standards were abandoned in the United States and several other countries, and a nonnumerical, holistic standard was adopted that incorporates both the quantity and quality of all of the information present in a given print. It is worth noting that the lack of a numerical standard has not been deemed the cause of any error (Cole 2005; U.S. Department of Justice [hereafter "DOJ"] 2006).

Within the holistic standard, an examiner assesses each friction ridge impression individually for the amount of information present in that impression. It is the total information, which takes into account both the quantity of information as well as the quality of that information, that establishes the sufficiency or insufficiency of an impression for individualization. Figure 1 shows a series of friction ridge impressions, recorded from the same finger, that demonstrate a progression from insufficiency (A) to borderline sufficiency (B) to sufficiency (C). Within the holistic standard, the sufficiency threshold is not defined (i.e., quantified) because much of the information an examiner evaluates is not readily quantifiable (see Figure 2).

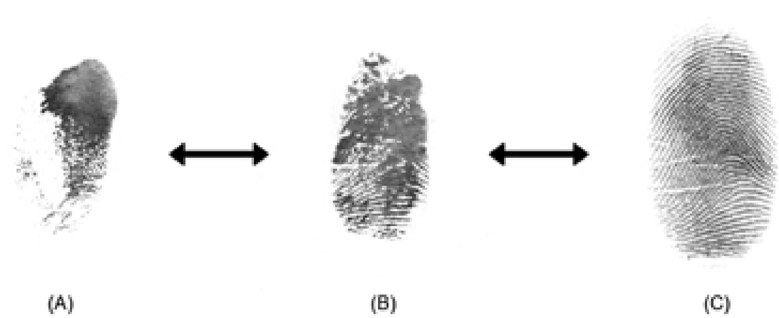

Figure 1: Three friction ridge impressions: (A) a small, distorted impression; (B) one of slightly better quality; (C) a clear impression

To appreciate how qualified forensic examiners apply the holistic standard, it is necessary to understand how examiners develop individual thresholds and how the laboratory system establishes the uniformity of these thresholds. An individual examiner’s threshold for sufficiency is predicated on the examiner’s education, knowledge, experience, and training (i.e., those attributes that constitute expertise). To determine the sufficiency of a given impression, examiners draw upon their knowledge gained from examining a multitude of friction ridge impressions during training and in actual casework, combined with their knowledge of the biology of friction ridge skin, the factors involved in the reproduction of skin and friction ridge impressions, and probability modeling of friction ridge arrangements. All of these factors combine to establish an individual examiner’s sufficiency threshold.

The uniformity of examiner thresholds is established through training by empirical study, consultation, and verification with experienced, qualified trainers. During the training process, new examiners develop thresholds through continual interaction with the trainer(s). This experiential approach enables trainees to learn the threshold other qualified examiners apply, thereby maintaining a consensus threshold within a laboratory system. Each individual examiner is not expected to develop the same exact threshold for sufficiency, but these individual thresholds should not vary significantly from the consensus threshold. In addition, the practices of consultation, verification, and proficiency testing within each laboratory system continually monitor the adherence of examiner thresholds to the consensus threshold. Because examiner thresholds develop within a specific training environment, consensus thresholds are expected to vary somewhat between training environments.

The lack of quantification of the sufficiency threshold is not an issue for the majority of friction ridge impressions. Given that most friction ridge impressions can be categorized as having either a wealth or a significant lack of information available, most impressions are easily determined to be sufficient or insufficient for individualization. Only those friction ridge impressions that lie near the sufficiency threshold require additional consideration. Friction ridge impressions near the threshold can be considered complex and thus may require additional quality-control measures, such as consultation, before they are determined sufficient or insufficient. If applying these quality-control measures does not yield a definite conclusion about the sufficiency of a print, then the examiner deems the print insufficient.

The lack of conventional quantification of the sufficiency threshold is mitigated further by the nonconsumptive nature of friction ridge examination. Any given friction ridge impression can be reexamined anytime if sufficiency is in doubt. Given a practical definition of sufficiency for individualization as “containing a volume of information such that one and only one source is capable of its production” (FBI 2007), the determination of sufficiency of any impression becomes objectively refutable by retesting.

Figure 2 illustrates the information that examiners consider during a determination of the sufficiency or insufficiency of a given latent friction ridge impression. The latent friction ridge impression appears in the center, and the information considered during the determination of sufficiency surrounds the latent friction ridge impression (A–F).

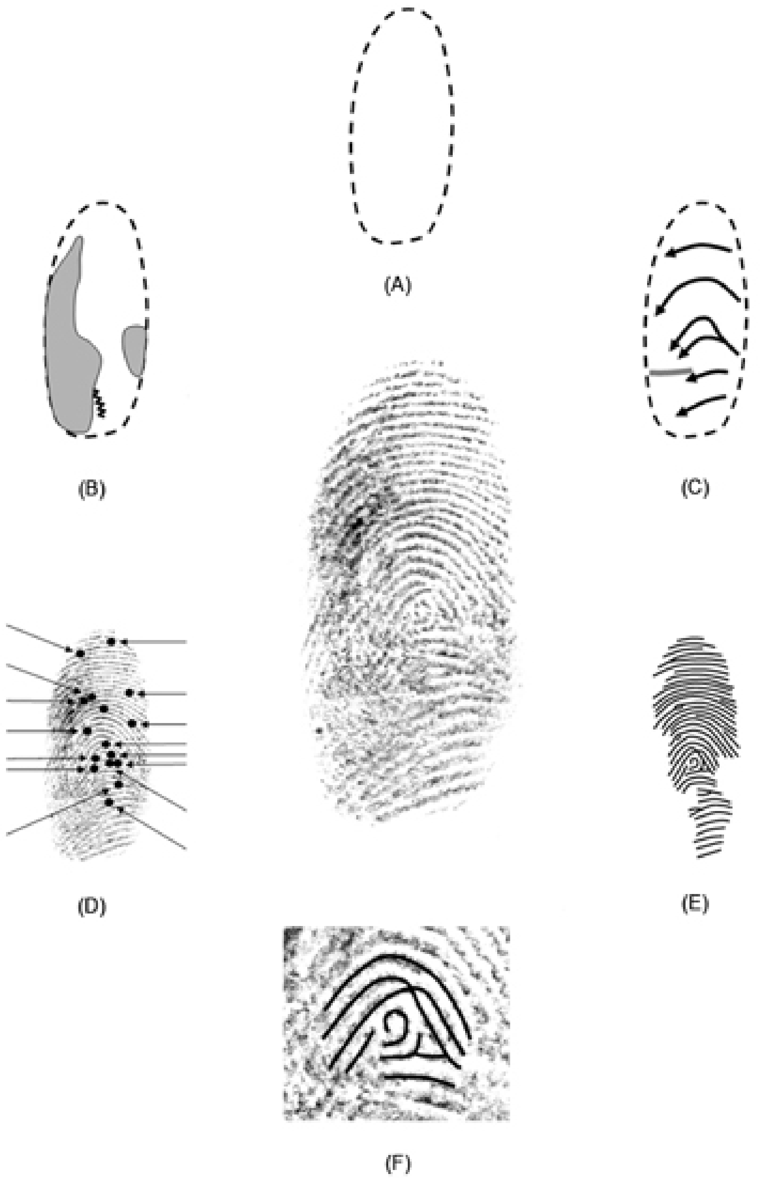

Figure 2: A series of illustrations demonstrating the information that latent print examiners consider when evaluating sufficiency (*n* = 60)

Figure 2A highlights the size and shape of the latent friction ridge impression. The size of the friction ridge impression correlates directly to the quantity of information contained therein, and the shape can indicate the source of the friction ridge impression. This friction ridge impression is consistent with direct deposition from the end joint of a finger. Further, it is inconsistent with the size and shape of an impression made from the lower joint of a finger or a palm.

Figure 2B highlights areas of distortion apparent in the latent friction ridge impression. The quality of the information is as valuable a consideration as the quantity, and the interpretation of information located in areas of distortion must be assessed appropriately. About one half of this friction ridge impression has some level of distortion, and consequently, all of the information in these distorted areas (areas of lower quality) requires greater scrutiny than the information in the low-distortion areas (areas of higher quality). The “zig-zag” line near the bottom of the impression highlights an area of ridge path misalignment. The paths of the ridges passing through this area also require greater scrutiny

Figure 2C highlights the overall flow of the friction ridges. The overall flow of the ridges can indicate the origin of the friction ridge impression in relation to the entire area of friction ridge skin. The flow of the ridges in the given friction ridge impression is consistent with coming from the end joint of a finger and further displays either a small loop or arch pattern. The gray line in the bottom third of the impression highlights the presence of a “white line” crease.

The arrows in Figure 2D point to the level-two detail ridge characteristics (ending ridges, bifurcations, and/or dots). Although much information is associated with each ridge of a friction ridge impression, these specific ridge characteristics are the easiest to quantify and illustrate. However, in the determination of sufficiency, even these characteristics are not merely

counted, but rather their value is based on the type, position, direction, and spatial relationship of each characteristic within the aggregate of all information.

Figure 2E highlights the paths of the friction ridges. The number, sequence, and lengths of the friction ridges all add to the information available to the examiner. Many of the ridge paths in this friction ridge impression can be followed with confidence, although the paths of some ridges become unclear as they enter distorted areas. These areas of uncertainty are represented by the gaps in the outlined paths.

Figure 2F highlights the individuality created by the aggregate of the friction ridges and their features. As illustrated by the lines that connect the features in the middle of the impression, the ridge flow, the ridges in sequence, and the ridge characteristics in sequence together provide the basis for sufficiency. By considering all of the information in the given friction ridge impression, an examiner can determine that this friction ridge impression lies well above the threshold for sufficiency for individualization and is therefore suitable for comparison.

By considering all of the information present in a given friction ridge impression, an examiner can reliably assess that information to determine sufficiency. This is a qualitative determination based upon the knowledge, experience, and training of the examiner. Furthermore, given the sufficiency of each friction ridge impression individually, this assessment of sufficiency continues through the comparison process as the examiner considers the combined information present in the comparable areas of both impressions (seeAppendix A).

Statistics and Probability Modeling

For more than 100 years, fingerprint pioneers and statisticians alike have attempted to quantify fingerprint individuality through statistical modeling (Pankanti et al. 2002; Stoney and Thornton 1986). Although no model of fingerprint individuality to date has been comprehensive enough for the fingerprint community to accept, the fingerprint discipline has benefited significantly from these studies, which have established general support for the premise of the individuality of friction ridge arrangements.

Statistics may play a more definitive role in the determination of sufficiency. Some experts have suggested that the holistic approach, which has been criticized as relying too much on the subjective interpretation of the examiner, would gain an additional measure of objectivity from a calculated sufficiency based upon statistical models of individuality. Although this proposal has merit, statistical models to date have considered only a portion of the information available in a given friction ridge impression (generally only a subset of level-two detail) and, as a result, are not robust enough to provide a reliable determination of sufficiency. We expect that continuing research into statistical models and their development may provide the foundation to establish a statistically based sufficiency standard.

The extrapolation of statistical models to the calculation of fingerprint “probabilities” represents a separate issue from the determination of sufficiency (Champod and Evett 2001). Some experts believe that probabilistic calculations should be considered the gold standard to which all forensic disciplines, including latent prints, should aspire (Saks and Koehler 2005, 2008). This argument demonstrates a certain naïveté regarding the disparate nature of the information considered in the various forensic disciplines. It is also possible that, in light of errors that have occurred in the latent print discipline, this argument represents a desire to mitigate the assertion of absolute certainty of individualization proffered by latent print examiners. However, the production of probabilities under these circumstances does not address the root issue, which is the question of error in a specific case (see Error section for additional discussion).

It is similarly possible that the call for probabilistic calculations may result from the various mandated and/or ill-defined thresholds for sufficiency held throughout the world. For example, an examiner may determine that two prints originated from the same source based upon all of the information present in the two prints but that the quantity of a specific subset of this information does not fulfill that examiner’s mandated numerical standard. In this situation, it makes sense that the examiner might want to determine how “probable” the identification may be, given that operationally the examiner is prevented from making the identification.

It is foreseeable that the debate over probabilities will naturally continue while the debate over sufficiency and error rate continues. Resolution of either the sufficiency or error-rate debate may lead to the resolution of the probability debate.

Errors and Error Rates

Types of Error

Scientists recognize three general types of errors that can occur in science: *systematic error, random error*, and *human error* (Skoog et al. 1998). Systematic error and random error refer to errors encountered with instrumentation or measuring devices in science; this is generally where the error rate for a scientific test is derived. Human error is generally treated

separately in most sciences, and in many sciences, it is not discussed as a rate or probability (Skoog et al. 1998). The following discussion addresses errors and error rates, both in general and as they specifically pertain to the latent print discipline. This discussion does not address cases of intentional misattributions, such as fabrication or fraud, because these are not truly errors.

Because latent print examinations do not employ instrumentation that can introduce systematic or random errors, the only general type of scientific error in the latent print discipline is human error, also commonly referred to as *practitioner error*. Instead of using instrumentation, examiners conduct visual comparative examinations according to the ACE-V methodology, which follows the scientific method.

Because no instrumentation can introduce error independent of the human being, it has been suggested that the ACE-V methodology may be a source of error in latent print examinations. The existence of such a "methodological error" would necessitate the existence of an inherent error in the experimental design of ACE-V. Although errors have occurred in latent print examinations, all of these errors have been attributed to the improper application of the ACE-V method (i.e., human error), and no errors have been attributed to the ACE-V method itself (DOJ 2006). For this reason, in the past, the "methodological error rate" has been somewhat confusingly stated as "zero" (Cole 2005; Wertheim et al. 2006). It is more accurate to say that the ACE-V methodology does not have a calculable error rate because it has no inherent error.

Within the latent print discipline, three general types of examiner errors exist: *administrative errors, erroneous exclusions,* and *erroneous identifications*. Administrative errors refer to simple clerical errors such as typographical errors. Administrative errors are not errors of data interpretation. The remaining two types of errors consist of error stemming from data interpretation. Erroneous exclusions refer to when an examiner fails to identify a print with a source when that print was in fact made by that source. Erroneous identifications refer to when an examiner concludes that two prints came from the same source when they did not (SWGFAST 2006). The erroneous identification is the most serious error in data interpretation that an examiner can make because it may falsely associate a person with an item of evidence.

Causes of Error

Examiners must be aware of several factors that may increase the potential for error in latent print examinations. Generally these factors can be grouped under two categories of bias: *contextual bias* and*confirmational bias*.

Contextual bias generally refers to the influence of additional or extraneous information on a decision-making process. If not cautious (or vigilant), an examiner may be influenced by the knowledge of specific case information (Ashbaugh 1991; Dror and Charlton 2006; Dror et al. 2005; Dror et al. 2006). Confirmational bias generally refers to the tendency for individuals to interpret information in a way that confirms their own preconceptions. For example, examiners may allow information from the known print to influence what they "see" in the latent print (DOJ 2006).

These potentially biasing factors exist in every scientific endeavor. To mitigate the effects of bias, examiners must be trained both to recognize biasing factors and to avoid being influenced by them. Continuing education can keep these topics fresh in an examiner's mind (DOJ 2006).

Study of Error

As with any other scientific endeavor that involves human beings, latent print examination is not infallible. Cases of erroneous identifications in latent print casework have been documented (Cole 2005; DOJ 2006; Stacey 2004). If an error occurs, the agency should investigate the situation, determine the root cause of the error, and implement the corrective actions necessary to minimize the chances that an error will occur or fail to be detected again (DOJ 2006; NRC 1996). In the past, some agencies' policies required removing the individual who made the error (Cole 2005), thus establishing a zero-tolerance policy for erroneous identifications. Today, however, agencies recognize that human errors do not necessarily equal examiner incompetence; highly qualified individuals can make errors. For example, the FBI Laboratory recognizes that errors can provide the opportunity for the advancement of the discipline by revealing weaknesses in the program and introducing the impetus to effect the improvements needed. After the investigation into the cause of and failure to internally detect the Madrid error, the FBI Laboratory's Latent Print Unit (LPU) implemented improvements to its quality assurance program to help detect errors and to reduce the chance of committing such errors again. This was done in addition to implementing corrective action for the individuals who committed the error and continuing education for all LPU examiners. Further study into possible causes of erroneous identifications and error detection methods, both in casework and in research settings, is warranted and should be sought continuously. This would assist in improving examiner training and laboratory quality assurance systems.

Error Rates

As a result of *Daubert v. Merrell Dow Pharmaceuticals* (509 U.S. 579 [1993]), courts may seek a "known or potential rate of error" for each method of each forensic science that can be used in a predictive manner (i.e., to give a numerical measure of

the chance that an error has occurred in the particular case before the court) (*Daubert* 1993). The calculation of error rates for instrument-dependent sciences can be fairly straightforward when one considers only the error of the system (i.e., the error of the instrument); the error rate is most generally defined as the number of errors committed over the total number of experiments/measurements (Wertheim et al. 2006). However, providing such a system error rate is different from calculating the contribution of error from the scientist (i.e., human error). Calculating human error rates is a complex undertaking, because unlike instruments, human beings change, learn, and adapt, particularly when faced with errors and the quality assurance systems designed to overcome these errors and improve practices. As a result, the chance that human errors will be made or repeated is constantly changing. Because latent print examinations employ no system beyond the examiner, the only error rate that can be provided is the human error rate. The error rates associated with automated fingerprint identification systems (AFIS) are distinct from error rates associated with latent print examinations because such systems only provide candidates for the examiner to compare and do not play a role in the latent print examinations themselves. Studies that attempted to assign probabilities of human error have been conducted in other applied sciences, such as nuclear safety (Swain 1983), but even in this field, research is ongoing to find the best, most appropriate model, because the assumptions for these models often are flawed or limited.

In the latent print community, it is generally thought that any calculation of error should include only erroneous identifications, because these are the only errors of consequence within the legal system. Also, no consensus exists as to whether an error rate can or should be discipline-wide, agency-specific, individual-specific, or reported in some other way. Nor, as has been discussed elsewhere, is it appropriate to use proficiency test results or laboratory audits to measure error rate (NRC 1996; Wertheim et al. 2006).

It has been proposed that an “error history” may substitute for the calculation of a human error rate. However, further study is needed to determine whether such an error history can be used effectively. In theory, it would be desirable in the latent print discipline to know the odds that the system will fail, not so much for a single component of the system that may be rectified by, for example, verification, but for the system as a whole—the original examiner, the verifier, the blind verifier (if used), and all other quality assurance and quality-control measures. Studies to determine this will be quite complex and will likely go beyond calculating error frequency for individual examiners, although this is an important factor. Preliminary studies on individual examiner error frequency have been conducted (Evett and Williams 1995; Wertheim et al. 2006), and research in this area is ongoing, but currently the discipline has no scientifically supported error rate. However, because latent print evidence is nonconsumptive, a reanalysis would be the best way to determine if an examiner made a human error in any case in question. After all, the concern of error is not whether an examiner could have made a mistake in a case, but whether the examiner did make a mistake in a specific case.

The State of Error Rates

In the latent print discipline, it is not yet known how to establish a direct correlation between error history and prediction of future errors or if it is even scientifically possible to do so. Although we do not currently have a numerical measurement of error rate, research is ongoing to determine what approaches may legitimately capture error-rate predictions. Irrespective of a numerical error rate, the goal will always be for each laboratory to have the best system in place to minimize the chance of having an error occur in the first place, coupled with every practical method of error detection. Laboratories can minimize error by properly training and testing examiners, ensuring that examiners diligently perform their jobs, establishing well-defined protocols, and adhering to the practices inherent in a strong quality assurance program.

Quality Assurance

Although not strictly a part of the scientific basis for latent print examination, a quality assurance (QA) program remains essential for producing a reliable work product. For a work product to be viewed as reliable, the employees who perform the work need to be competent, perform the work properly in specific cases, remain proficient, and stay abreast of changes and updates in their field of expertise. In addition, the materials used by the employees must meet quality standards, and the equipment must be calibrated and maintained according to a regular schedule.

A solid quality assurance program should be described in a quality manual that includes instruction on all aspects of the quality system and the correlation between the policy and the accreditation body. Documented standard operating procedures (SOPs) should be included as a significant part of this manual. The following paragraphs outline elements of the current QA program employed in the Latent Print Unit of the FBI Laboratory, an ASCLD/LAB-accredited laboratory. Other laboratories and agencies may vary in policies and practices while still producing a reliable work product.

Audits

Scheduled audits ensure that quality standards are being met. These audits need to be both internal and external. An internal audit is a systematic analysis of several functions within the laboratory to assess whether the employees and the laboratory

produce a work product consistent with the laboratory's quality system. Examples of internal audits include case file, court testimony, training records, continuing education, proficiency testing, security, control of standards and reagents, instrument calibration, document control, and evidence security.

An accrediting entity usually performs external audits or assessments. External audits typically focus on the same areas of concern as the internal audits. If the laboratory has successfully completed these audits and assessments, the users can rest assured that the policies and procedures in place within the quality system allow the laboratory to produce a quality work product.

Case-File Reviews

A periodic review of the case files ensures that the quality system meets the needs of the customer. This review establishes whether the laboratory has the necessary equipment, expertise, and procedures to meet requests for service. If the laboratory meets the required needs, the review also establishes whether case reports contain accurate information to allow for the interpretation of the results. Case-file reviews should include both technical and administrative reviews of the work product.

Conflict Resolution

The potential for conflict between examiners or agencies always exists. A quality system allows for the conflict and uses the resolution process to ensure both that accurate results are reported and that the proper steps in the resolution process are taken to address the reason for the conflict. During the process of conflict resolution, the examiner or the supervisor may decide that additional documentation is required to assist with any subsequent reviews.

Conflict resolution is different from consultation with other qualified examiners. Consultation should be encouraged, especially when newer examiners can benefit from discussions with more experienced examiners, and sometimes vice versa. Other examiners may have experienced difficult analyses, examinations, or unusual circumstances and may have knowledge that will assist in the examination. At times newer examiners can bring a fresh look to a problem. The need for consultation is not necessarily a good indicator of complexity, especially when different experience levels are involved.

Continuing Education

Continuing education allows examiners to feel confident that the procedures they use are valid and the most up to date. Management should encourage employees to attend conferences, workshops, and other training opportunities. Relevant periodicals should be available and used in the education process. At the FBI Laboratory, all forensic examiners have access to an extensive forensic science library and experienced staff to obtain research and continuing education materials.

Corrective Action

When corrective actions are necessary, the first course of action should be to determine the root cause of the problem. If the root cause can be determined, then proper corrective steps can be initiated. If the root cause of the problem is determined to be related to policy or equipment, it is a chance to modify a policy or update the equipment. If the root cause is determined to be related to the examiner, then the corrective actions should be viewed as a chance for rehabilitation. Corrective actions should not be viewed as punitive but as a chance to detect, correct, and improve on any situations or conditions that are affecting the quality and integrity of the work product. If corrective actions do not improve or eliminate the root cause, then additional administrative action must be considered.

Equipment Calibration and Maintenance

The laboratory must maintain any equipment used during the examination process in proper working condition. If calibration will ensure that the equipment works properly, then the laboratory should formulate and follow a regular calibration schedule.

Proficiency Testing

Proficiency tests are a critical evaluation of an individual's ability and should be given annually. If an error is detected on a proficiency test, the laboratory should determine the root cause of the error. Based on the source of the error, a review of the examiner's work product may be initiated that includes a sampling of all finished work product since the last successfully completed test. This review should determine if additional corrective steps are necessary before the examiner is assigned any new casework. Before resuming casework, the examiner should demonstrate competency by successfully completing another proficiency test.

Testimony Monitoring

The testimony of every examiner should be routinely monitored. Testimony can be evaluated by any court official or reviewed for technical accuracy by a subject-matter expert who either directly observes the testimony or reviews a transcript. At least

one testimony should be monitored annually.

Training Program

Each examiner should complete an internal training program if not previously tested for competency. When training is provided in-house, a robust training program must be in place that covers all aspects of the discipline. The training program should contain detailed information, with milestones identified for continued skills development. The program also should identify what milestones examiners must meet to complete the training and what actions should be taken when examiners fail to meet these milestones.

Competency Testing

Before beginning casework, all examiners should be competent to perform the required procedures. Whether an examiner was trained within the laboratory or previously trained before being hired, all examiners must be competency-tested before beginning independent casework.

Validation Practices

Any technique used to process evidence for latent prints or produce results that are to be reported must be validated prior to use in casework.

A solid quality assurance program is not a static entity, but it should continue to evolve with the needs of the discipline and the requirements of accrediting bodies. The LPU QA system itself has evolved significantly over the years. Prior to being transferred to the FBI Laboratory Division in 1992, the LPU followed the basic practices required by a QA system; however, these practices were not as documented or comprehensive as the Laboratory's current accreditation process requires. This earlier QA system did capture important information—such as activities performed, documented analysis and subsequent conclusions, transfer of evidence, and the disposition of the evidence. However, the subsequent accreditation requirements, along with the current QA system, have created policies and prosidures that are significantly more robust.

Case-File Documentation

Documenting work activities represents a key component of a QA system that supports the reliability of a specific work product. Such a record allows for the review of activities if the quality of a specific work product comes into question or if an error is detected. Laboratory accrediting bodies generally dictate minimum requirements for documentation. ASCLD/LAB *International* Supplemental requirements for the accreditation of forensic science testing laboratories, which form the basis for the current FBI LPU documentation requirements, define documentation requirements: (1) Documentation must be sufficient so that another analyst could evaluate what was done and determine if the conclusions are supported and (2) Documentation must meet all applicable requirements in Appendix A (latent print-specific documentation requirements) (ASCLD/LAB 2006b). The following paragraphs outline elements of the documentation requirements set forth in the FBI Latent Print Unit SOPs.

Chain of Custody

All evidence transfers should be captured on a chain-of-custody report. This documentation should originate at the crime scene and continue through the disposition of the evidence. The disposition may be that the evidence was mailed, transferred to another entity, or delivered to court. The chain-of-custody report accounts for the possession and proper handling of evidence to prevent contamination, cross-transfer, or the loss of items during the time the evidence is in the possession of the examiner.

Crime Scene

Case documentation is not complete if the record-keeping process does not begin at the crime scene. Documented information should include the circumstances of the crime, crime scene photographs or sketches or both, and any other pertinent information that would assist the investigators, latent print examiners, or the courts in the successful completion of the investigation.

Evidence Collection

Documentation of evidence collection should include any items collected for transfer to the laboratory, any items processed at the scene, the processes used at the scene, and any latent print lifts or photographs produced. This documentation should include a unique identifier for each item, a chain-of-custody report with each item documented, and a record of the surfaces from which any lifts or photographs were taken.

Evidence Processing

Once the evidence has been received in the Latent Print Unit for processing, case-note documentation should chronologically include each activity and the results of the activity. Documentation should include any development techniques applied, the date the process was applied, and the result. The documented result should include the presence or absence of any prints and the indication of whether the developed prints are suitable for capture either through scanning or photography. This documentation process should continue until all processing techniques have been applied or the processing is discontinued.

Examination of Latent Prints

Case documentation should indicate the number of latent prints of value detected on each item, along with a description of the item, and which items did not contain any latent prints or latent prints of value. Additional requirements include the disposition of any images containing latent prints of value and any images of latent prints that were not analyzed, compared, or evaluated.

The original examiner, the verifier, and the blind verifier should each annotate a separate photograph(s) to be retained as part of the case documentation. Each photograph should be marked with the type of print and its anatomical position, the level-two detail used to render the conclusion (if an individualization), and the conclusion reached. The verifier and the blind verifier should sign and date their respective photographs and indicate which type of verification they conducted. This information should also be recorded in the case notes.

Analysis

Proper documentation of the analysis phase should include marking sufficient level-two detail on the photograph with a dissecting needle or ridge counter prior to conducting a comparison. Additional annotations on the photograph should include the orientation of the print, if it can be determined, and the type of print. Known exemplars, although subject to analysis, should not be annotated. The FBI Latent Print Unit uses the following markings to signify prints "of value" for individualization on photographs:

- Fingerprint: Draw a horseshoe-shaped mark over the top of the print. The examiner may indicate that the print is from the tip or side.
- Lower joint: Draw one line on each side of the print with the notation "LJ."
- Palm print: Draw a bracket at the bottom of the palm print with the notation "PP."
- Impression: Draw a circle around the print indicating that its anatomical source cannot be determined, and make the notation "IMP."
- Position unknown: If the type of print is known but the position is unknown, mark the print according to the type, and indicate the position as unknown by the notation "pos ?" or "position ?"
- Toe print: Draw a horseshoe-shaped mark over the top of the print with the notation "toe."
- Footprint: Draw a bracket at the bottom of the footprint with the notation "footprint."

Comparison

Proper documentation of the comparison phase should include marking on an additional photograph with a dissecting needle or ridge counter the level-two detail used in the comparison, if different from the analysis. Marking level-two detail is not required for exclusion or inconclusive conclusions. Additional annotations on the photograph should include the orientation of the print, if it can be determined, and the type of print. Known exemplars should not be annotated.

Evaluation

The evaluation phase should be recorded on the photograph and in the notes. If the print is individualized, the photograph should also contain "Ø," the individualization symbol; the correct finger or palm designation; and the individual's name and identifying information, if known. This information should also be captured in the case notes along with a specific description of the item where the latent print was found. The absence of the individualization symbol, name, and finger or palm designation on the photograph indicates an exclusion. For exclusions, the notes should include a statement specifying the total number of latent prints determined not to be prints of the individual(s). Inconclusive decisions should be annotated on the photograph by the notation "inconclusive" or "inc," in addition to the name of the individual and identifying information, if known and when appropriate. For inconclusive determinations, the notes should include a statement specifying the total number of latent prints determined to be inconclusive with the prints of the individual(s).

Verification

The verification phase includes independent analysis, comparison, and evaluation documented on a separate photograph(s). Independent analysis and documentation allow for identifying potential errors committed in the "ACE" of the first examiner or the "V" of the second examiner and proper conflict resolution or root-cause analysis if the need arises. All individualizations are subject to verification.

Proper documentation of verification should include all documentation requirements described previously for the analysis, comparison, and evaluation phases. Additional documentation should include the annotation that these photographs are part of the verification phase, as well as the verifier's signature and the date of the verification. The verifier should sign and date the identification in the case notes as well.

Blind Verification

Blind verification entails the independent application of the ACE methodology to a friction ridge impression by another qualified examiner who does not know the conclusion of the original examiner. Blind verifications may be conducted on individualizations, exclusions, and inconclusive decisions. At the FBI, blind verification is performed in cases when a "single conclusion" is reported (i.e., one individualization to one individual or one exclusion or one inconclusive to any number of individuals). Blind verification may be performed in other cases as determined by the examiner or supervisor (see Complex Prints). Proper documentation of blind verification should include all documentation requirements for the verification phase with the additional documentation that this is a blind verification on the photograph(s) and in the case notes.

Complex Prints

When explainable differences (i.e., differences due to distortion) or other factors influencing the quality of a latent print are present and their presence could interfere with the proper interpretation of the print, the analysis and resulting conclusion should be considered complex and documented in the case notes and, if possible, on the photographs. If a complex print requires consultation or enlargements, then the notes of the consultation or a copy of the annotated enlargements should be maintained in the case notes. This documentation should include notations regarding consistencies, explainable differences, pressure distortion, discrepancies, and any relevant information to assist in the correct examination.

Secondary Evidence

Any secondary evidence, such as a lift or photograph of a nonrecoverable latent print, should be accounted for in the case documentation as secondary evidence and tracked by a secondary evidence log.

Reports

Reports should be supported by case documentation and include a summary of the examiner's results, to include any conclusions reached and the disposition of the evidence. Examiners should not issue reports unless they have participated in the examinations or have conducted a thorough review of the case documentation.

As with all other aspects of quality assurance, documentation requirements have evolved over the years. Historically, documentation in the latent print discipline had been minimal when compared to other scientific endeavors. Over time, additional documentation requirements have developed from necessity, and others have derived from legislative mandate. Many current requirements have derived either from corrective actions that occurred in the past or from the requirements from accrediting bodies such as ASCLD/LAB.

Training

Because the criminal justice community increasingly relies on forensic examination as a primary investigative tool, forensic laboratories today face an ever-increasing number of cases. To compound this situation, a shortage of qualified latent print examiners exists because of a lack of funding to staff these positions and a lack of consistency in the education, training, and skill level of latent print examiners. To increase the number of qualified latent print examiners and maintain the consistency and accuracy of latent print examinations, the latent print community needs to determine the minimum qualifications necessary for latent print examiner trainees, establish a standard training curriculum and certification program that can be implemented nationally, and require annual proficiency testing of certified latent print examiners.

Qualifications

In the past, finger print examiners were required to have, at a minimum, a high school diploma. The FBI balanced this minimum educational requirement by hiring candidates with significant experience in classifying and filing fingerprint cards. Over the years, higher demand for scientific and analytical capabilities for the fingerprint discipline has prompted the FBI and

some other laboratories to increase the minimum qualifications to require at least a bachelor's degree, whereas other laboratories require a bachelor of science degree, with a master's degree preferred.

SWGFAST has set forth guidelines for the minimum qualifications for latent print examiner trainees (SWGFAST 2002b). SWGFAST recommends that individuals possess, at a minimum, a bachelor's degree from an accredited college or university. Given the increased focus by the courts on the scientific foundations of the forensic sciences in general and the push to expand and strengthen these foundations, it is foreseeable that the minimum qualifications for latent print examiner trainees may in the future require a bachelor's degree in science, including courses in chemistry, biology, math, and statistics.

Training

The intensity, length, format, and subject matter of latent print examiner training vary widely across the discipline. A latent print examiner may have as few as two weeks or as many as two years of training (the FBI Laboratory prefers the latter). With such a difference in the amount of training received, the skill level of latent print examiners varies immensely.

SWGFAST has also published a guideline for training latent print examiners to competency (SWGFAST 2002c). The guideline covers recommended subject areas by outlining required and supplemental training objectives. The guideline states that successful students must demonstrate knowledge of required objectives by passing written tests and/or practical exercises and by communicating an understanding of the objectives and underlying principles. It also strongly recommends that students demonstrate knowledge of supplemental objectives. Although the guideline provides a good foundation for the knowledge desired for competent latent print examiners, it does not address the structure of a qualified training program.

A qualified training program, or standard curriculum, should include a standard list of topics to be covered, the number of hours to be spent on each topic, texts to be read, and tests to be taken. Standard comparison exercises also should be included so that the complexity and number of comparisons conducted remain consistent. This will help to ensure that trainees achieve a consistent skill level in training. The tests for this training also should be standardized with a set minimum passing score.

The program should include an Apprenticeship/Mentorship component so that trainees can apply the training to actual casework under the direct supervision of an experienced examiner. The Apprenticeship/Mentorship program should have a standard length of time and a predetermined number of cases to be worked, number of comparisons to be conducted, and number of identifications to be effected during a specified time period. By meeting these requirements, the student demonstrates the ability to consistently render reliable conclusions. At the completion of the training program, the trainee should be given a standardized certification test. This test should include both a comprehensive written test and a comparison examination. After becoming certified, examiners would be required to take an annual proficiency examination to maintain their status as certified latent print examiners.

To create consistency in the training of latent print examiners across the discipline, the latent print community needs to establish nationally accepted training standards. A standard curriculum could be instituted several ways. Three of these are outlined in Appendix B. Instituting one, or a combination, of these three training options would greatly increase the number of qualified latent print examiners available to work in crime laboratories. Incorporating standardized training would create more consistency in skill level and knowledge throughout the discipline. Increasing the number of funded latent print examiner positions available, in combination with standardized training, would greatly improve turnaround times of cases in laboratories across the country, as well as provide consistent and accurate results in a timely manner.

SWGFAST

SWGFAST establishes consensus guidelines and standards for forensic friction ridge examinations. Established in 1995, SWGFAST originally focused on forensic latent print examinations. In 2007, SWGFAST added a Ten-Print Fingerprint Standing Committee. As a result, SWGFAST also will create guidelines and standards for ten-print examinations and operations.

SWGFAST membership consists of up to 50 individuals from international, federal, state, and local forensic science laboratories as well as from private practice. Members include latent print examiners, ten-print examiners, attorneys, academicians, research scientists, and laboratory managers.

As of May 2009, SWGFAST has published the following documents (see http://www.swgfast.org):

- *Friction Ridge Examination Methodology for Latent Print Examiners.*
- *Glossary.*
- *Minimum Qualifications for Latent Print Trainees.*

- *Model Policy for Friction Ridge Examiner Professional Conduct.*
- *Quality Assurance Guidelines for Latent Print Examiners.*
- *Standard for Friction Ridge Automation Training (Latent/Tenprint).*
- *Standard for Friction Ridge Comparison Proficiency Testing Program (Latent/Tenprint).*
- *Standard for Friction Ridge Digital Imaging.*
- *Standard for Simultaneous Impression Examination.*
- *Standards for Conclusions.*
- *Training to Competency for Latent Print Examiners.*
- *Validation of Research and Technology.*

Through these documents, SWGFAST intends to guide the community so that competently trained examiners can perform quality forensic examinations by adhering to standard operating procedures linked to a strong and committed quality assurance program. This in turn produces accurate and reliable conclusions.

Although SWGFAST guidelines and standards are widely recognized by the forensic community, the legal system, and forensic laboratory accrediting bodies, agencies and practitioners are not required to follow them. Until standards are nationally mandated, as has been done with DNA typing, the forensic friction ridge discipline remains without a means to enforce adherence to these guidelines and standards.

Recommendations

We provide the following recommendations as suggestions for the advancement of the latent print science. These recommendations should be implemented with an added focus on establishing greater communication and uniformity in both training and practices across the latent print community.

- Encourage continuing research into the factors (e.g., pressure, amount of substance being transferred, etc.) that contribute to the appearance of friction ridge impressions and, in particular, how each factor affects the quantity and quality of information present in a given impression.
- Establish guidelines for latent print examiner testimony with the goal of more accurately conveying the basis, standards, significance, and limitations of the examiner's conclusions.
- Encourage the development of metrics by which both the qualitative and quantitative information in an impression can be measured. Such metrics could improve the standard for sufficiency by establishing a holistic sufficiency standard that can be applied more objectively and uniformly across the discipline.
- Support the development of a "comprehensive" statistical model that more accurately incorporates the information taken into account by the latent print examiner.
- Encourage continued study into the causes of examiner error, both in the laboratory and in casework.
- Encourage continued study into detection methods for error, especially erroneous identifications, both in the laboratory and in casework.
- Establish minimum standard qualifications for latent print examiners.
    - Require at least a bachelor's degree in science.
- Create more uniformity in training and skill level by establishing a national standard training curriculum and certification program, using three possible options:
    - Develop a national latent print examiner school.
    - Have latent examiners at all levels of government attend a training program at a federal laboratory.
    - Institute latent print examiner training as part of a college or university degree program.
- Require annual outside proficiency testing across the discipline to maintain certification.
- Establish legislation mandating adherence to standards established by SWGFAST or a nationally recognized governing body.

Conclusion

The latent print discipline is well founded on the premises of persistence and individuality. Friction ridge examination is based solidly upon the ACE-V methodology, which follows the scientific method and is bolstered both by the application of rigorous standards for its conclusions and a robust quality assurance system. Although areas for improvement of the discipline—such as determining the sufficiency of latent prints and latent print examination error rates—exist, the science of friction ridge examination as a whole is both relevant and reliable.

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Appendix A

The following figures provide visual representations of information that examiners consider during latent print comparison. Because the human brain is capable of analyzing and comparing more information than can be effectively illustrated here, these figures are not intended to represent all of the information examiners consider during the comparison process.

Figure 3 illustrates the information examiners consider when comparing two friction ridge impressions; in each group, labeled A through D, as well as the top two impressions, the image on the left is a latent print and the image on the right is the known exemplar.

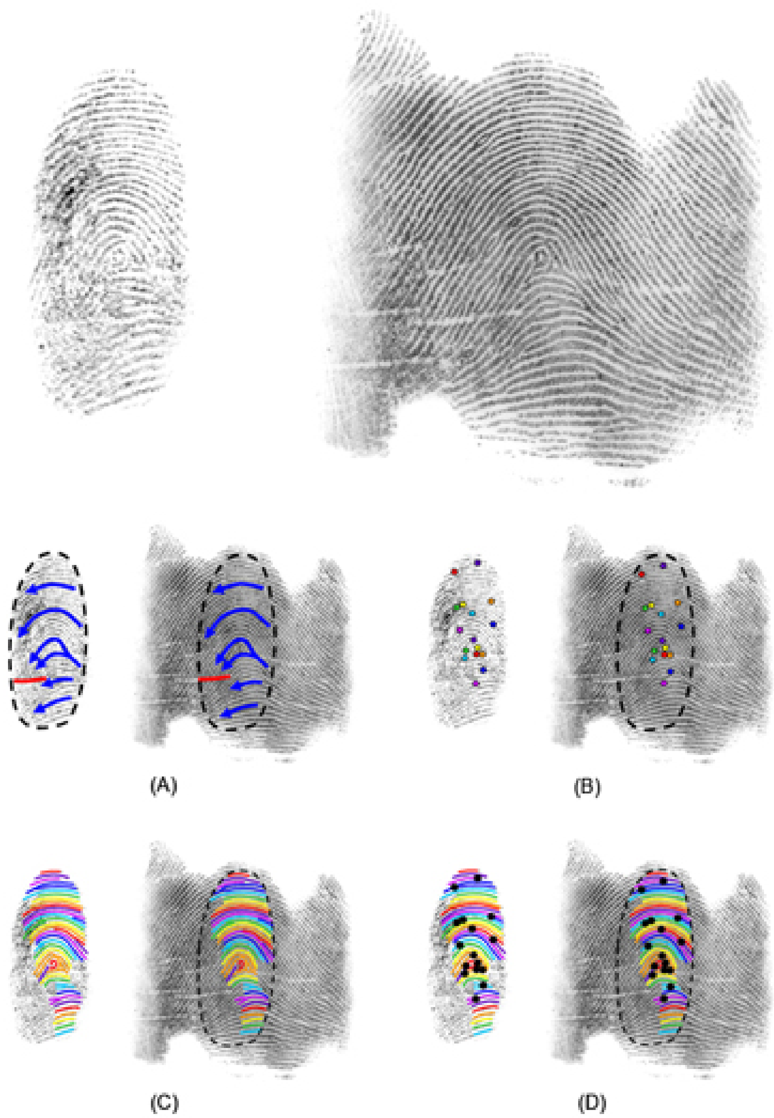

Figure 3: Colored lines and dots note corresponding features on the latent prints on the left and the known exemplars on the right.

Figure 3A illustrates information present at level-one detail. The six blue arrows that run from right to left throughout the impressions represent the ridge flow present in each print, and the red line near the bottom left represents the presence of a “white line” crease. The ridge flow provides the means to quickly orient and correlate the comparable area to the known exemplar. Although in this figure the corresponding area of the latent print is completely recorded in the known exemplar, it is important to note that this is not always the case. The question of sufficiency continues throughout the comparison process and, in particular, when the corresponding area of a latent print is not fully recorded in the known.

In Figure 3C, the colored lines throughout the impressions indicate the paths of the individual ridges in sequence by color. Note that no dots or paths are illustrated in areas of noted distortion. This does not imply that these distorted areas are devoid of information useful for comparison, merely that the information contained in these areas requires greater scrutiny. In Figure 3D, the colored lines illustrate the ridges in sequence, and the black dots illustrate the ridge characteristics in sequence. Together, these exemplify the agreement of the information and the absence of any conflicting information.

When comparing friction ridge impressions, examiners select a starting point from the latent print at their discretion. This starting point can be a small grouping of features, a specific ridge path, or a focal point such as a delta, core, scar, or crease. The examiner then compares the orientation of these ridges and features in the corresponding area within the known exemplar. If there is conformity between the two impressions, then the examiner proceeds by systematically assessing the ridges in sequence and the characteristics in sequence throughout the latent print and determining the agreement or lack of agreement with the known exemplar. It is important to note that the quality of the known exemplar is an integral part of the

comparison process and can play as much of a factor as the quality of the latent print.

Figure 4 illustrates how the quality of friction ridge impressions can impact the comparison process. Figure 4A shows an enlargement of the core area of the latent print (left) and known exemplar (right) used in Figure 3. Figure 4B illustrates the level-three detail present in each of these friction ridge impressions. The known exemplar (right) is of exceptional quality, and the edges of the friction ridges and the positions of pores are indicated by the black outlines and red dots, respectively. The latent print (left) is of lesser quality and does not support the comparison of level-three detail.

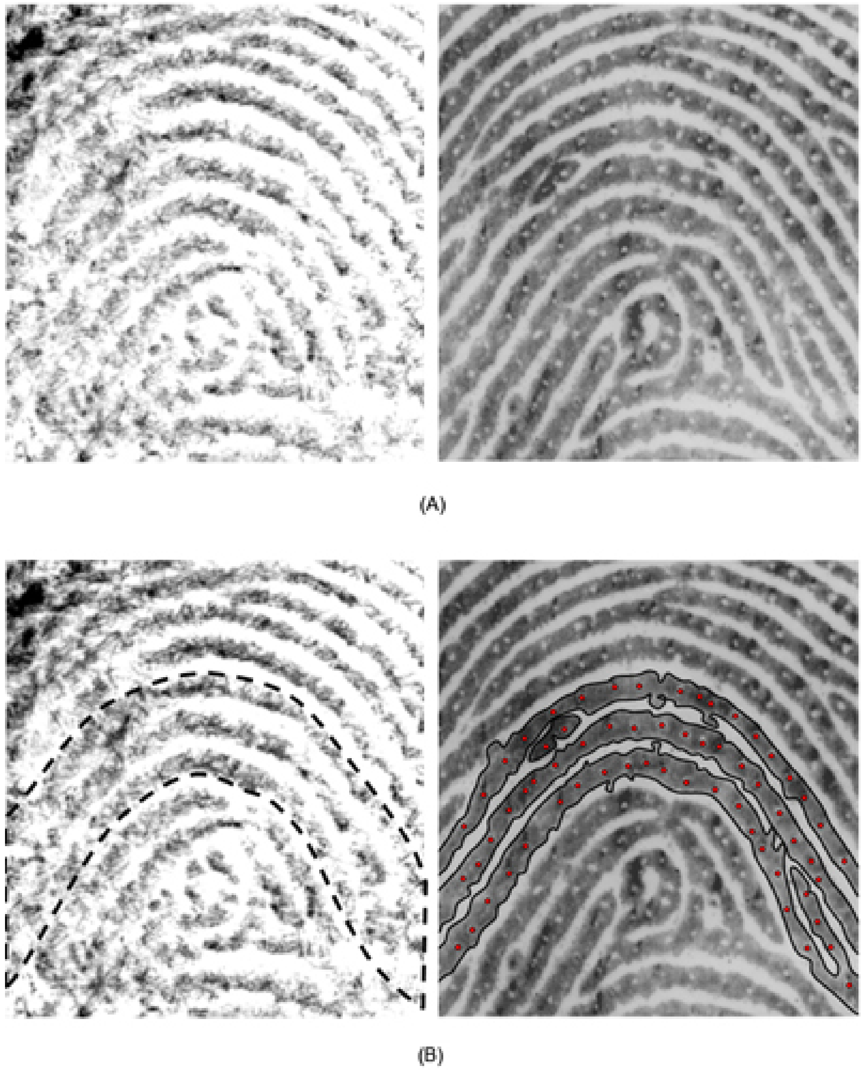

Figure 4: The enlarged latent print on the left lacks the quality of the known print on the right. This lack of quality is evident in the loss of the level-three detail discernible in the known print.

Although the comparison process begins with the latent print and moves to the known exemplar, the examiner must seek out features in the known print that do not exist in the latent print. These features provide the examiner with an effective and efficient means to reach an exclusion.

Figure 5 depicts an exclusion scenario. The impression on the left is the same latent print shown in Figure 3, and the impression on the right is a known exemplar from a different source finger, an exclusion. The inset enlargements in Figure 5 highlight the ridge paths within the core area of the impressions. Although these two fingerprints are similar in their general shape and size of the pattern area, they are easily distinguishable when compared. Interestingly, the known exemplar in Figure 5 comes from the same finger (a left index finger) as the known exemplar in Figure 3 but comes from the monozygotic twin of the donor.

Figure 5: The latent print on the left is different from the known exemplar on the right, demonstrating an exclusion.

Appendix B

In the following paragraphs, we present three proposals for the creation of a nationally standardized training program for latent print examiners.

Proposal 1: National Latent Print Examiner School

A national latent print examiner school could be created to train latent print examiners to competency and provide a consistent level of training throughout the discipline. This school should be nationally funded and staffed with highly qualified latent print examiners and instructors. Newly hired individuals from local, state, and federal laboratories would attend this school, or individuals could apply to the school directly and then enter a job-placement program from which laboratories would choose candidates. The Apprenticeship/Mentorship phase of the program would consist of an internship at approved crime laboratories, where the trainee would work under the close supervision of a highly qualified latent print examiner. The laboratories and mentor examiners would need to apply and demonstrate their qualifications before being accepted into this program.

The advantages of this type of program are that initial/fundamental latent print examiner training becomes more centralized and helps to ensure that all latent print examiners receive consistent and thorough training. As a result, the skill level throughout the discipline would increase and become more consistent.

The disadvantage of this type of program is that experienced caseworking examiners would necessarily be removed from laboratory casework in order to staff the school with instructors. This may lead to a larger number of unworked cases initially, but would eventually increase the number of cases worked in the future by providing additional qualified examiners.

Proposal 2: Federally Based Latent Print Training

A federal laboratory could be selected to conduct training following a standard curriculum. The laboratory would need additional funding and staffing to take on this added responsibility. Advantages to having the training conducted in a federal laboratory are the availability of a wide range of casework and highly qualified examiners for the Apprenticeship/Mentorship phase of the training program. After a few years of conducting this training at the federal level, satellite programs could be initiated at other laboratories. The satellite programs would be directed by examiners who have successfully completed the training program at the federal laboratory, because they would be the most familiar with the format and progression of the program. These examiners would be eligible to instruct in a satellite training program once they have gained several years of experience as certified examiners and have become senior/master examiners at their respective laboratories. It also would be advantageous to have these examiners become certified instructors through a training program conducted at the federal laboratory. The satellite laboratories could train their own employees as well as employees from local laboratories. Satellite programs would be monitored closely to ensure compliance with the federal program.

Proposal 3: University-Based Latent Print Training

A standard latent print examiner training program could be instituted as part of a college or university degree program. This plan would take most of the funding responsibility away from the government and place it on the educational institution.

However, this plan would likely generate less interest than the other two options, because the majority of undergraduate college programs would focus on a more general course of study. This program could be offered as part of a master's degree program and include a job-placement program to make it more attractive to potential students. This type of program would need to be closely monitored and coordinated because it would be available at a number of different schools. Those monitoring the program would need to ensure that a standard curriculum is being followed and that the classes are being taught by highly qualified latent print examiners or other appropriately experienced individuals.